Bridge Management System: an Italian Experience SAGGI

Fare clic per modificare lo stile del sottotitolo dello schema

International Bridge Forum, Kings' College, Cambridge, UK, 13th-16th September 2009

Bridges 2020: Management for Long Term Bridge Performance

Management

Management = continuous process that commences at the concept stage and applies throughout the key stages of the existence of any construction (i.e. bridge, building, tunnel,….)

Key role represented by surveillance, monitoring and assessment

Goal = to know the conditions of structures, to predict their future behaviour and to assess their maintenance needs

For owners and operators

Economic Strategic Importance of themes such as:

- efficient inspections
- effective maintenance
- optimal management

As time goes by and structures deteriorate and approach the end of their service life, these aspects, together with their associated costs, will progressively and relentlessly become more and more important with a large incidence on the budget of public and private owners and operators, thus impacting either on taxation or on tolling

Problem

Fundamental = to develop solutions, technologies, processes and products aimed at:

- guaranteeing the safety of users
- increasing the durability of structures
- increasing safety against hazards (i.e. earthquakes)
- reducing maintenance and rehabilitation costs
- increasing transport capacity
- improving the safety of employees and workers

Rules in Italy for surveillance of bridges and tunnels (1967)

General Inspections

- Assessment of the conditions of all structures related to the infrastructure
  - every 3 month (technical personnel)
  - each year (trained engineer)

total:1+4 = 5

Report

- Inventory data
- Dates of inspection
- Names of the inspectors
- Results of the inspection
- Maintenance interventions (if any)

Notice: For railways the interval is 6 months

Rules in Autostrade

General Inspections: STONE (1986)

- 3-month inspections
- ratings from 1 (good conditions) to 7 (bad conditions)

Principal Inspections: SAMOA-Surveillance, Monitoring and Maintenance of bridges

- every 1-2-5 years according to the state of deterioration
- defects (catalogue of 112 defects)
- 7 classes of deterioration

Time to…

Re-thinking of the system (procedures and guidelines):

- inspecting and modeling of structures
- performance of structures in time in function of traffic loads
- performance of structures in time in function of seismic loads
- Decision Support System

While taking advantages of the developments in technologies and research

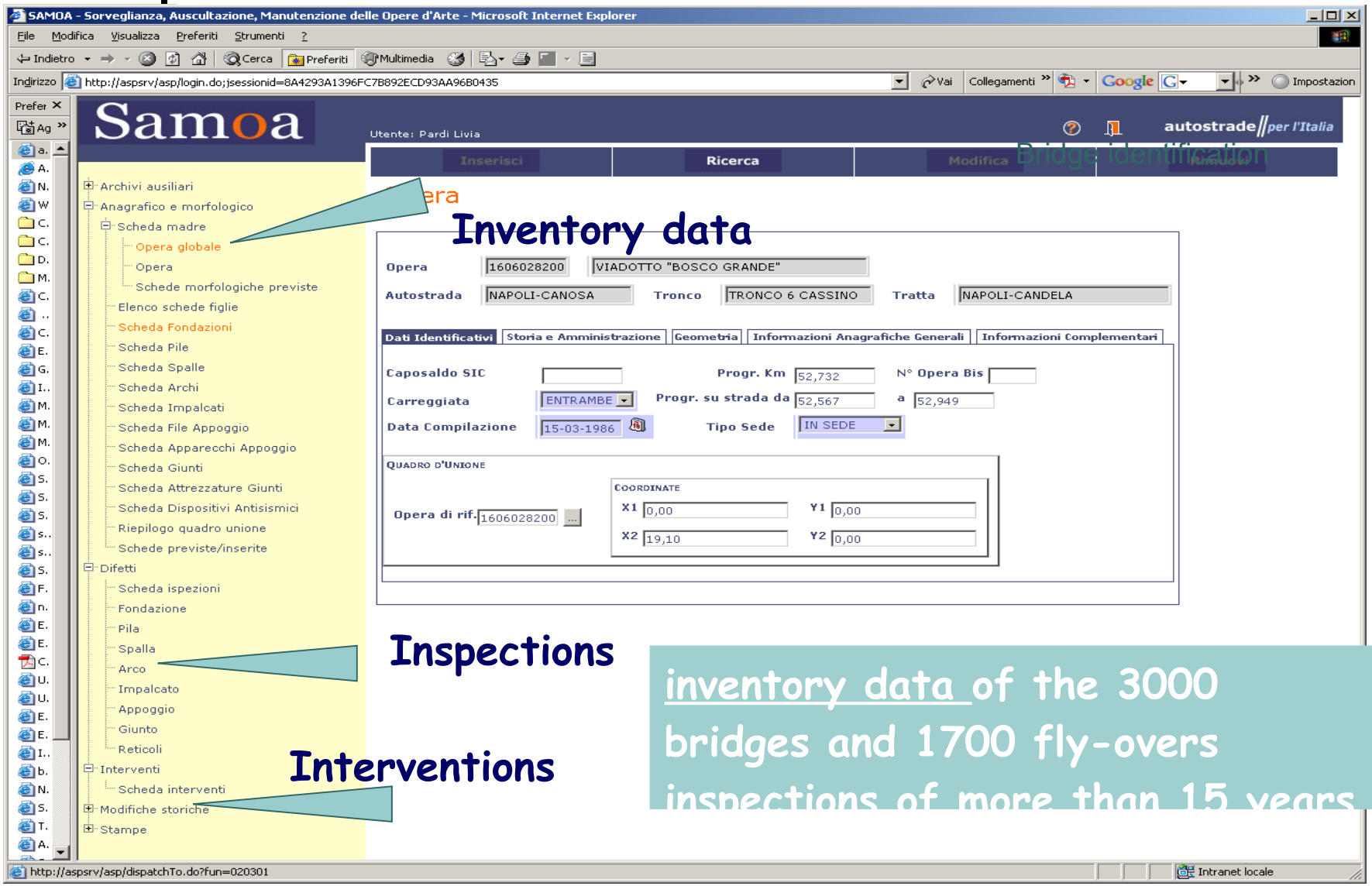
S.A.G.G.I. - Advanced Systems for the Global Management of Infrastructures

The project aimed at developing an integrated bridge management system covering the different aspects of surveillance and assessment, allowing the treatment of both visual and instrumental data

The results of the projects represent a strong support to evaluate actual and future conditions of the network thus resulting in a more precise input for maintenance planning

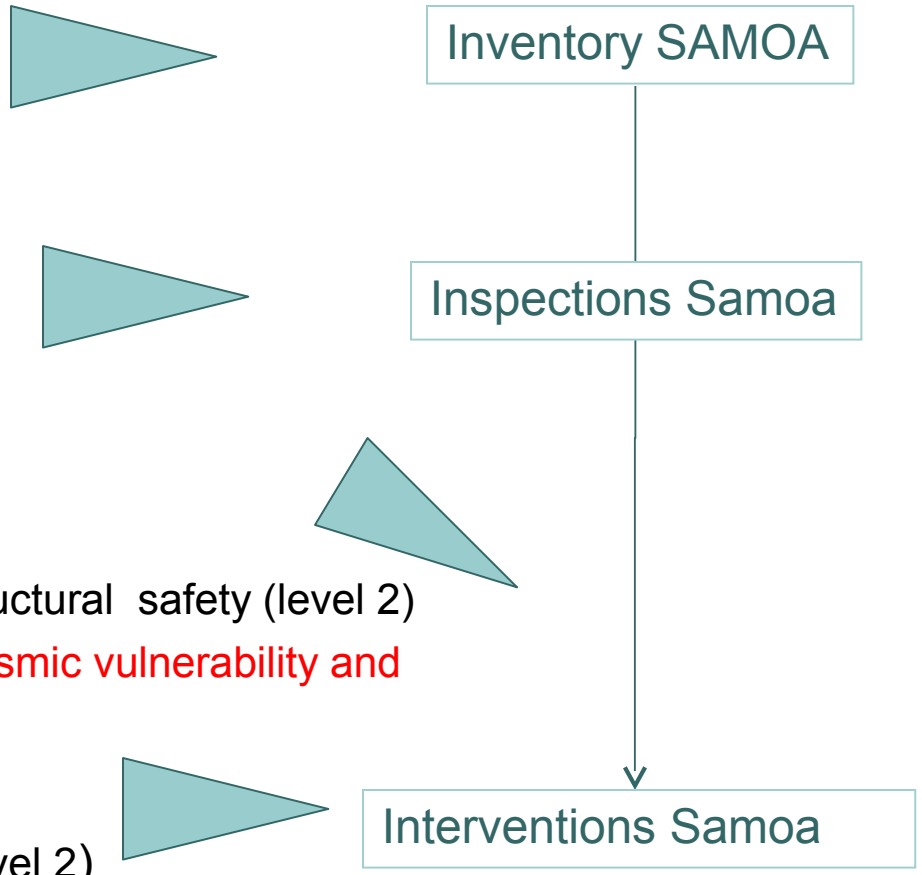
Research project financed by the Italian Ministry for Research (2005-2009)

General data



Additional modules SAGGI

- Structural data
- Seismic (structural) data
- Inspections
  - 3 D inspections
  - Automatic recognition of defects
  - Porting of SAMOA on tablet PC
- State of the network
  - From visual data (level 0)
  - Algorithm for the evaluation of the structural safety (level 2)
  - Algorithm for the evaluation of the seismic vulnerability and risk (level 2)
- Decision Support System
  - Priorities of interventions (level 0 – level 2)



Upgrading of visual inspections

Application of innovative technologies for the automation of visual bridge inspections, traditionally carried out by trained personnel

The proposed solution is based on :

- the use of a 3D laser scanner and a digital camera to quickly acquire a rich documentation of the surface of the structure to be analysed
- an automatic classifier of the scanner cloud points to identify the different morphological parts of the structure to relate the surface images to
- an expert system able to extract from laser scanner data different types of 2D images representing the surfaces of interest and to detect and classify specific deterioration
- a photorealistic 3D presentation of the status of the surface of the structure, linked to the Company's data base, as an aid for the maintenance staff

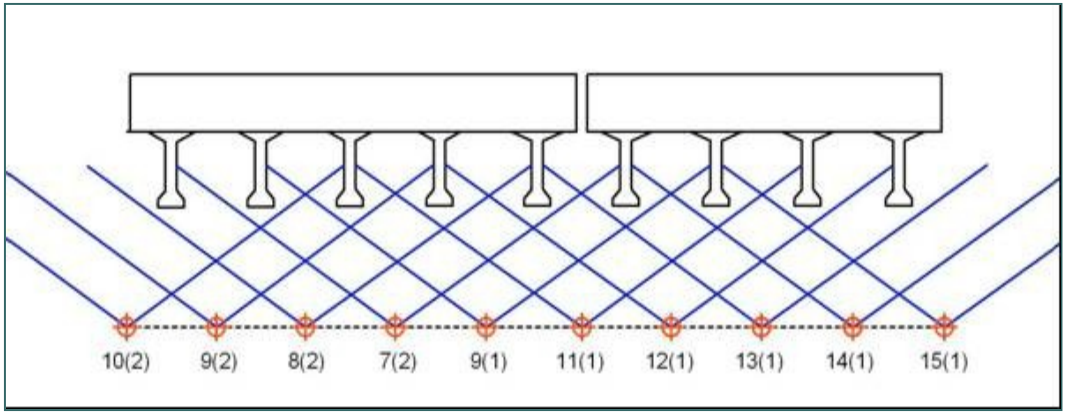
Limits of the actual system

- Duration of inspections
- Impact on traffic
- Time to upload and transfer data
- Lack of automatization
- Interpretation of results
- Assessment of structures
- Costs

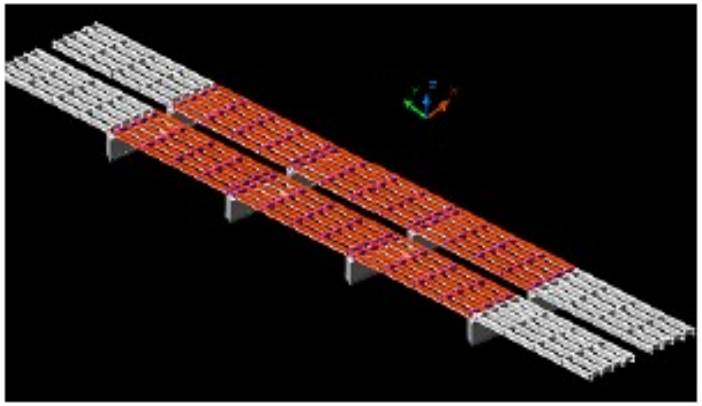
Tested

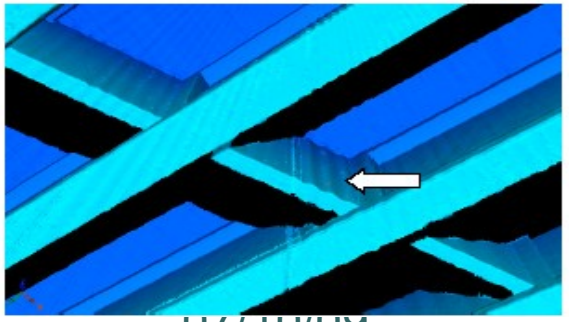
- Different laser scanners (speed and resolution)
- Different cameras
- Different acquisition proceedures
- Different laser parameters (reflectance)
- Other techniques: Thermography

Problems



- Traffic induced vibration
- Wind
- Time for acquisition (scanning resolution)





Results

Target:<= actual inspection (2 hours)

Bridge	Type	Speed per scanning position +photos	Time per span (hours)	Post processing (hours)
Bridge 1	beams and cross beams	>30 min	>5	-----
		4 min	>2,5	>10
		150 sec no foto	2	3
Bridge 2	beams and cross beams	100 sec	2	3
		62 sec	0,45	1,5
Bridge 3	beams and cross beams	62 sec	1	1,5
Bridge 4	box girder	62 sec	10 min	1,5

Automatic recognition of defects

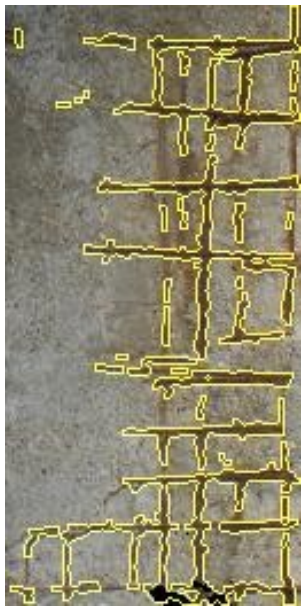
Automatic recognition of defects (approx. 50 out of 112)

Only concrete bridges (decks and piers)

- Reinforcement
- Prestressed reinforcement
- Concrete
- Cracking
- Water

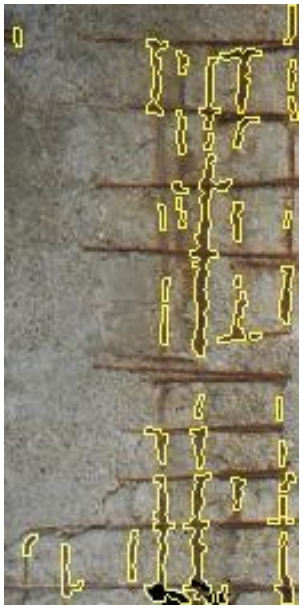
Reinforcement

Corroded reinforcement

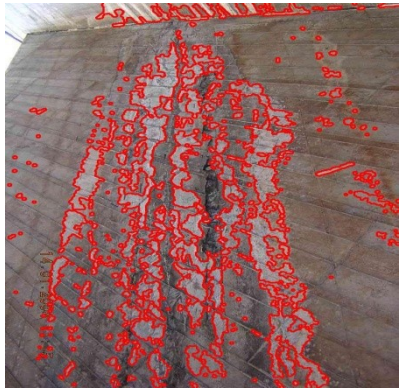


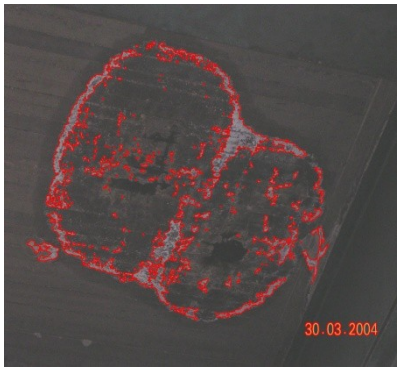
Horizontal reinforcement (stir-ups)

Vertical reinforcement



Water

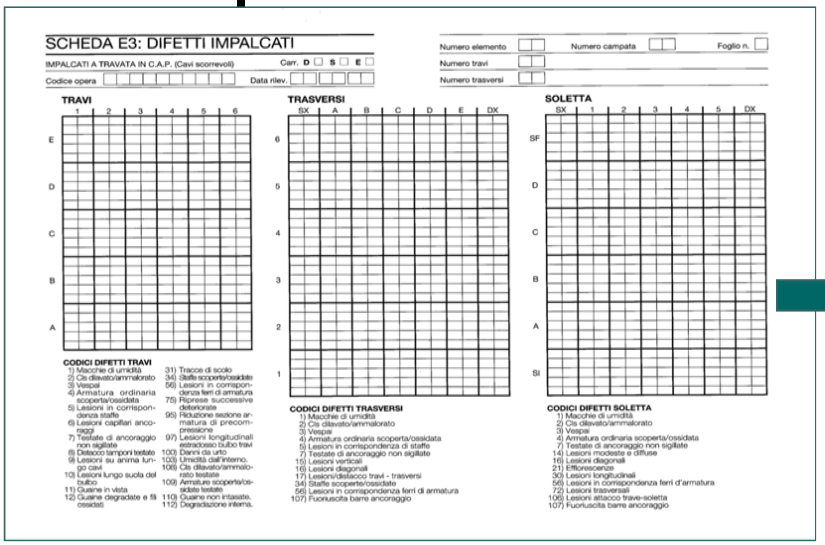


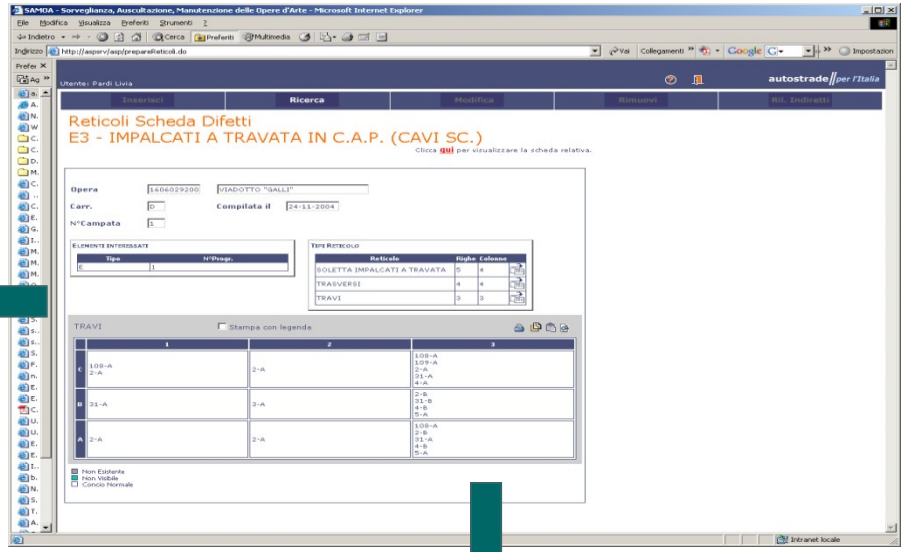


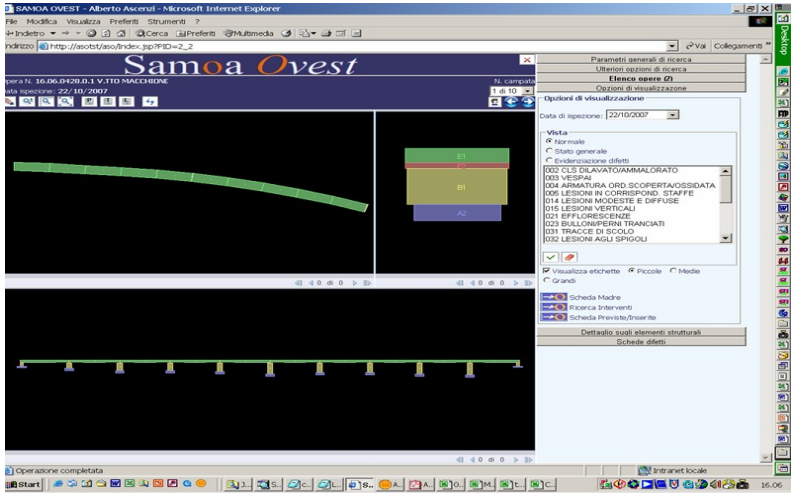
1818

07/10/09

2D □ 3D







1919

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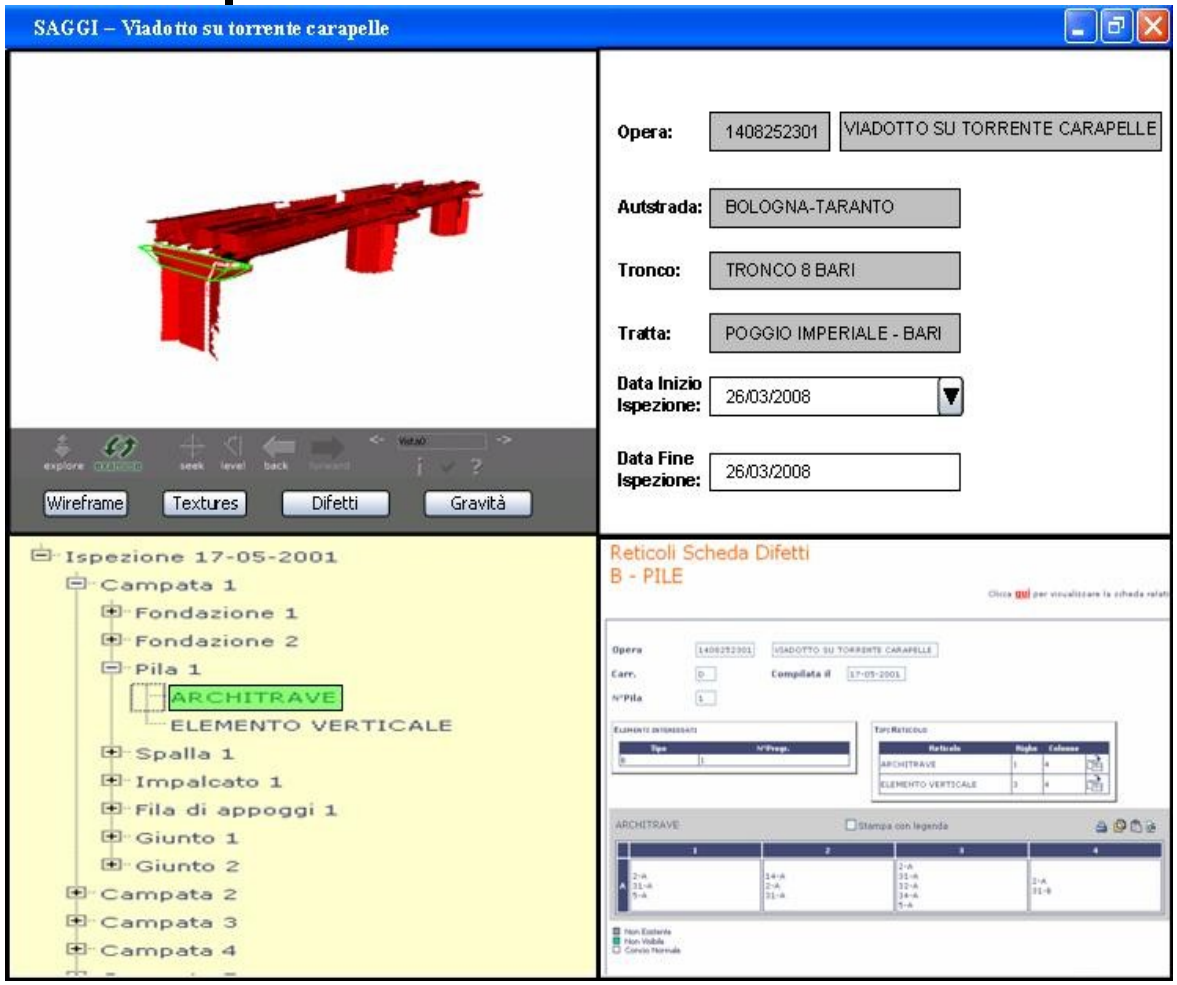
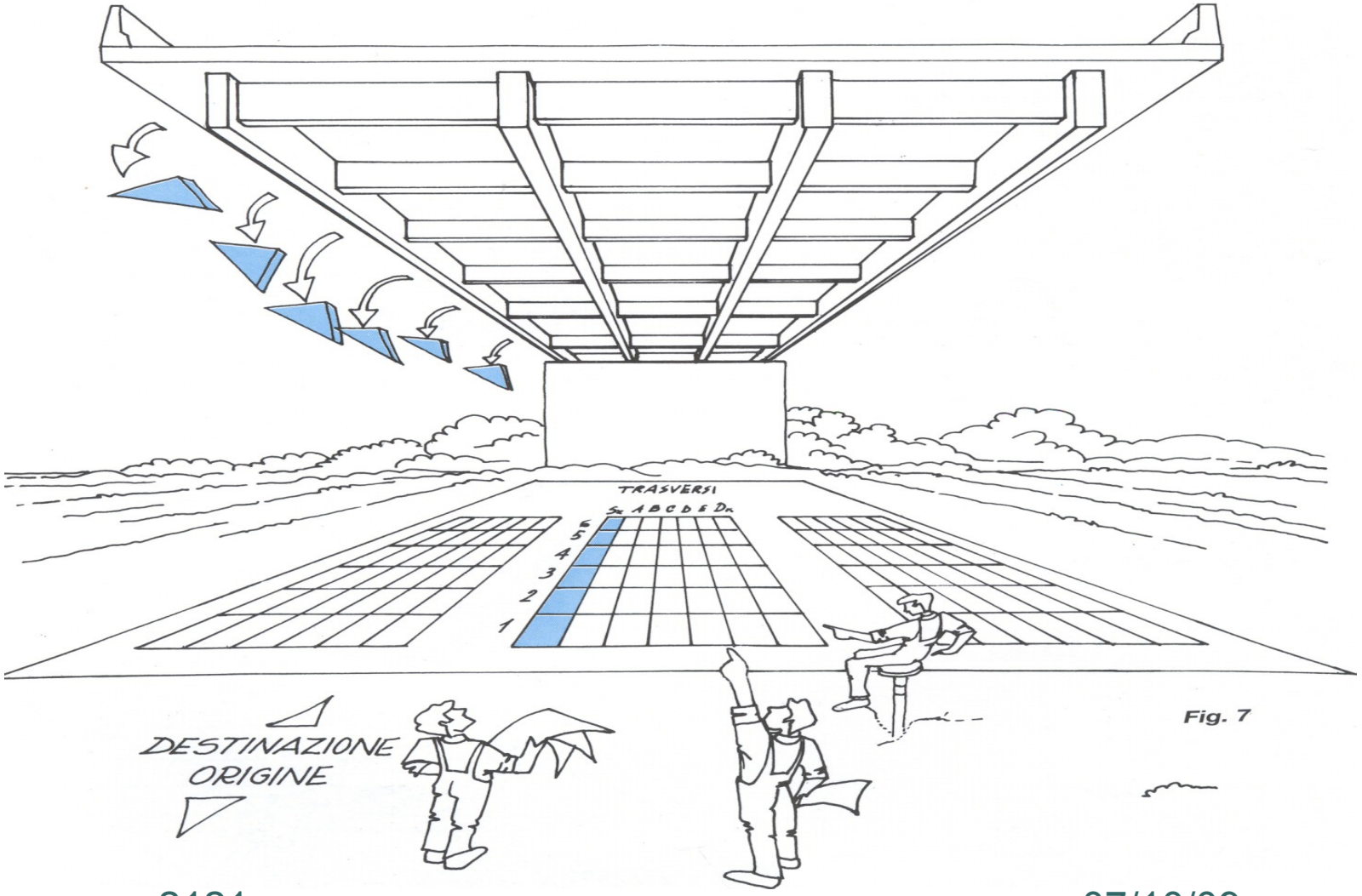
New Format



- Web based
- Possibilitiy of rotating, translating, zooming the 3D model
- Possibility of visualizing all the smallest elements of the structure
- Possibility of visualizing the defects both on the 3D model and on the old format

Discretization of the structure



Further topics to be explored

Acquisition of the geometry

- Improve the speed of data processing (hardware and software)
- Improve speed of on-site operations: development of a robotic arm mounted on a truck

Automatic recognition of defects

- Validate and calibrate the procedure (defects)
- (Extend the procedure to other structural parts and defects)
- Improve speed of data processing
- Improve the web page

In two-year time

Evaluation of the seismic behaviour

- Assessment of bridge conditions and understanding of their behaviour, in function of deterioration, both under service loads and in case of earthquakes
- Corrosion of reinforcement = main cause of deterioration
- Consequences = Reduced service life
  Need for maintenance interventions
- Assessment of both theoretical and numerical models, validated by laboratory tests on large-scale beams, artificially corroded, to assess the structural relevance of deterioration and to evaluate the residual load-carrying capacity of bridges.
- Predictive models = the input of the assessment of seismic risk

Problem

- Many existing bridges designed without adequate consideration of the seismic risk
- The seismic zonation map in Italy has been revised recently, prescribing more severe peak ground accelerations in several regions
- Reliable methods for assessing the seismic vulnerability of existing bridges were needed

Approach

In the project two different approaches for the assessment of seismic risk were developed:

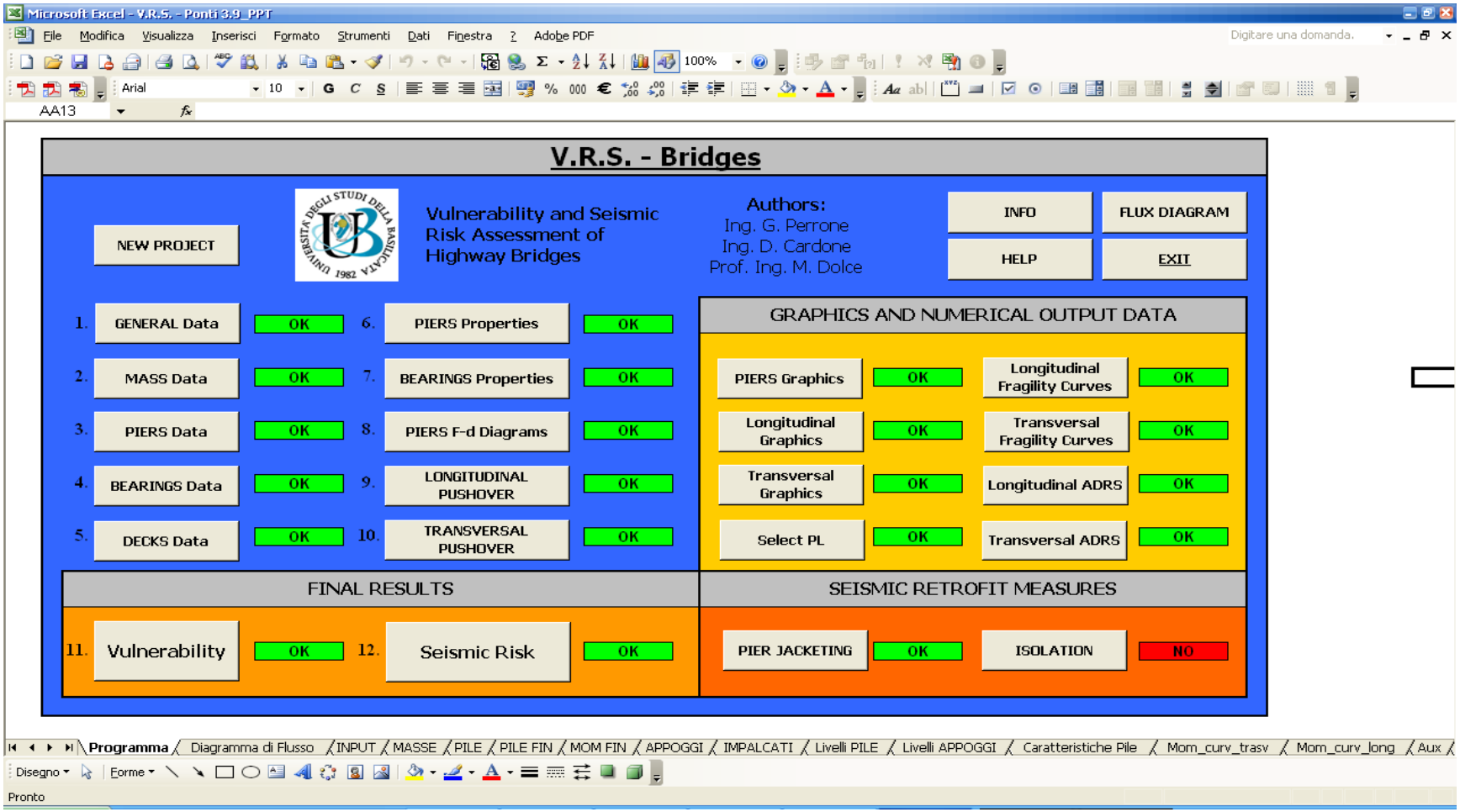
- Level 0. The first approach is based on the assignment of proper ratings to different characteristics of each structural element (piers, abutments, bearing devices, etc.).

Goal = It mainly aimed at prioritizing and screening operations

- Level 2. The second approach is based on the use of Fragility Curves, associated to different performance levels of the bridge, and then combined with a representation of the seismic hazard of the site.

Goal = It mainly addressed to an accurate assessment of the seismic risk of the bridge

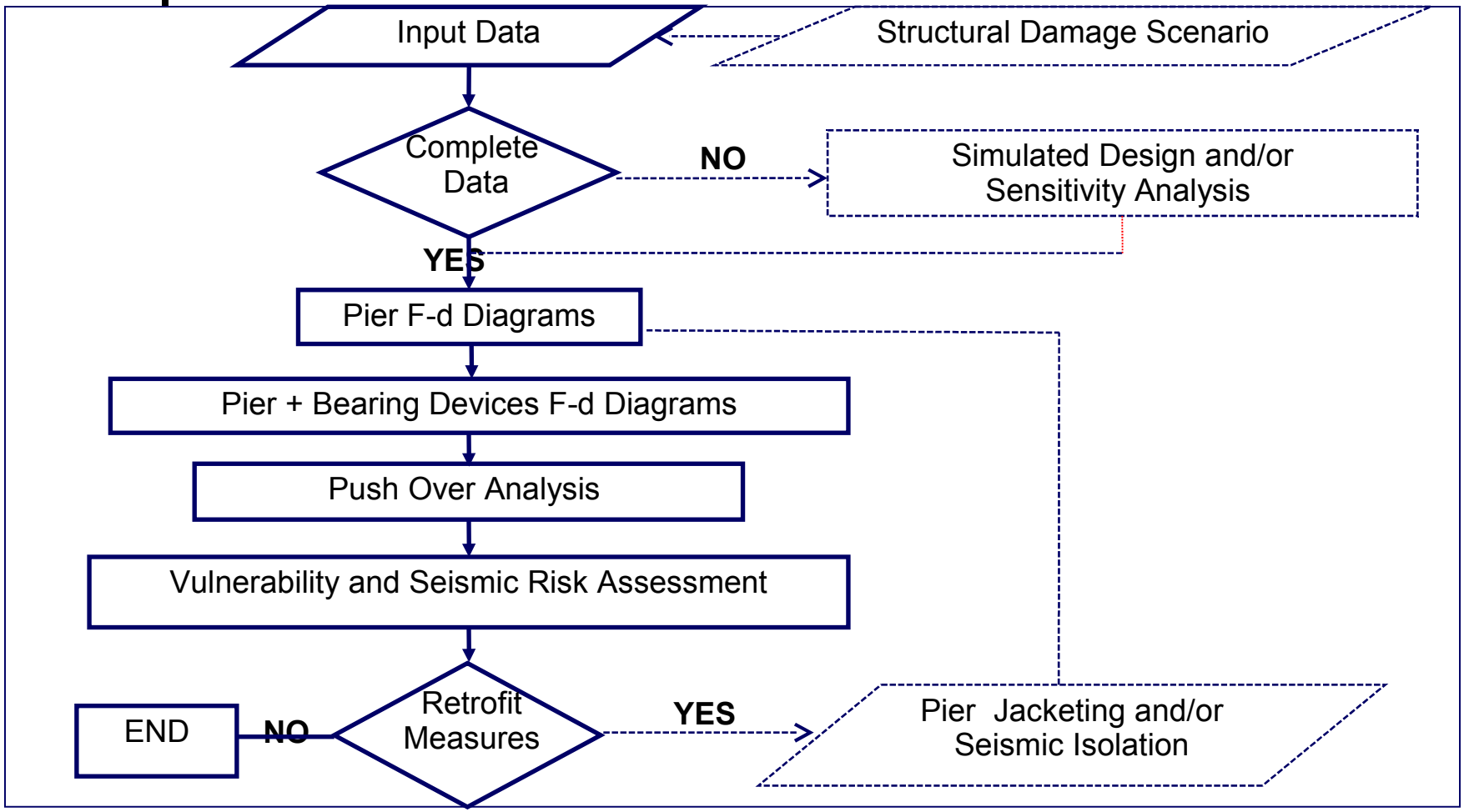
Proposed procedure (level 2)



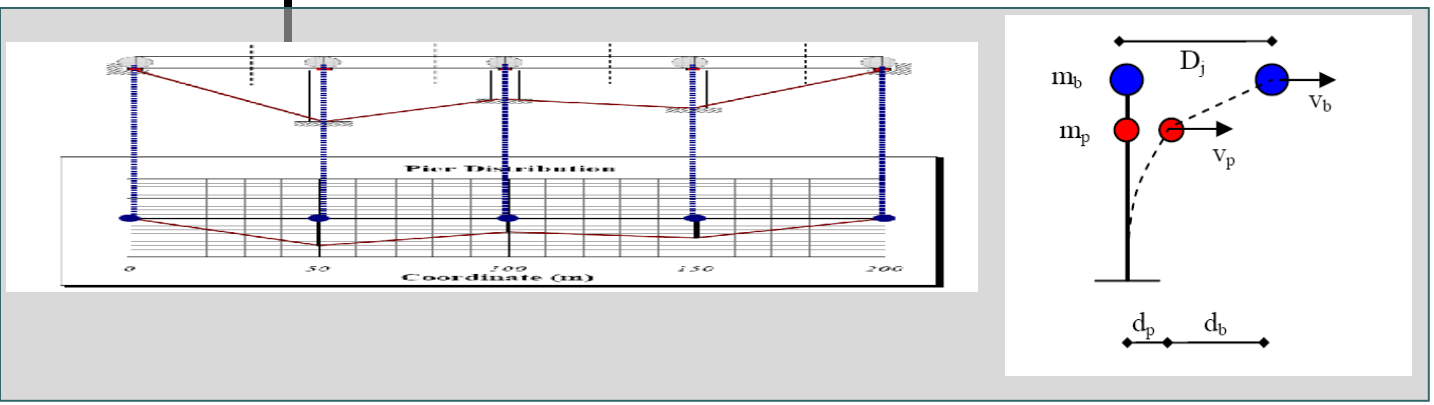
Evaluation of seismic behavior

- Detailed Input Data of the bridge structure (structural types of decks, piers, pier-deck connections and bearing devices)
- Adaptive Pushover Analysis for the characterization of the seismic resistance of the structure
- Seismic vulnerability expressed through fragility curves (i.e. P(DS>PL) vs. PGA) associated to selected performance levels
- Seismic risk obtained from hazard maps combined with fragility curves
- Ability to operate for different performance levels
- Possibility to account for different damage scenarios and/or retrofit measures

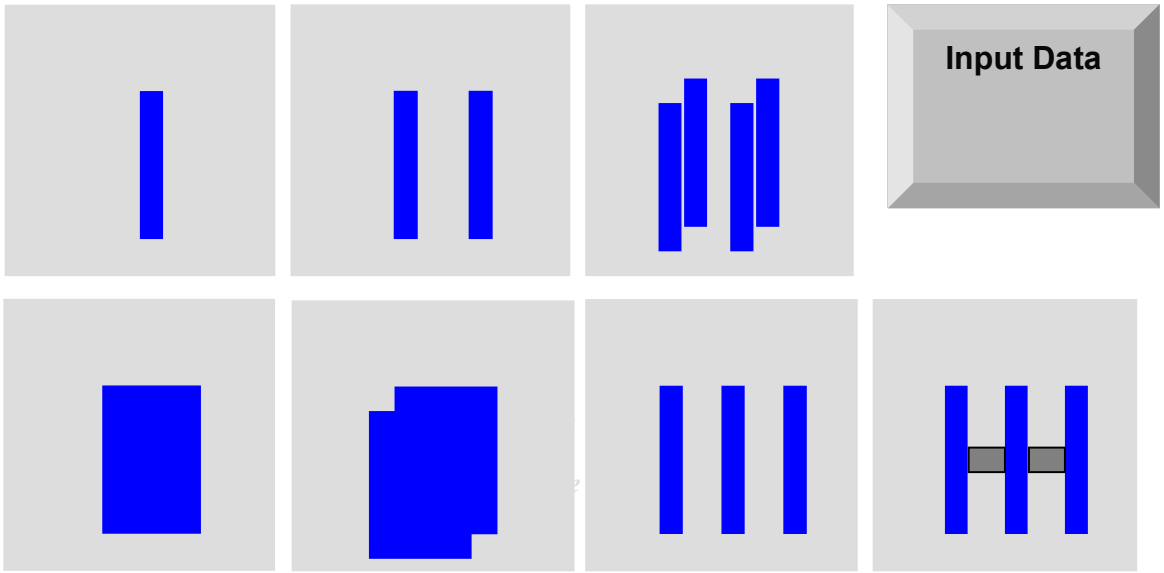
Basic steps of the procedure



Input data (1/2)

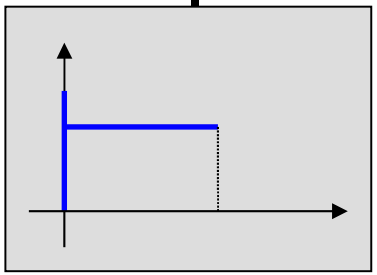


Input data (1/2): Bridge geometry, Masses, Resp. Spectrum

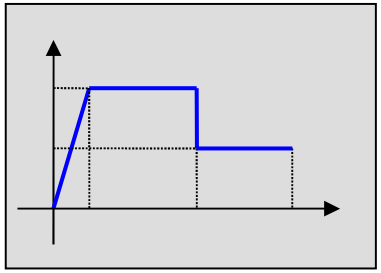


Input data (2/2): Pier Types, Materials, Reinforcement, Structural Decay

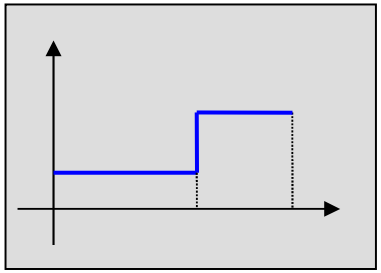
Input data (2/2)



Steel Hinges

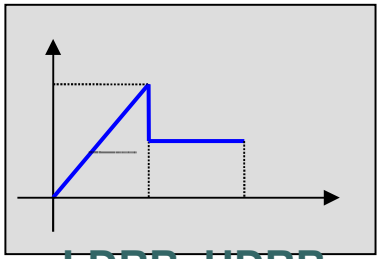


Neoprene Pads

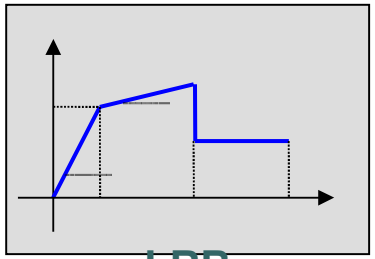


Steel Rollers, RC/steel pendulum, steel-PTFE FSB

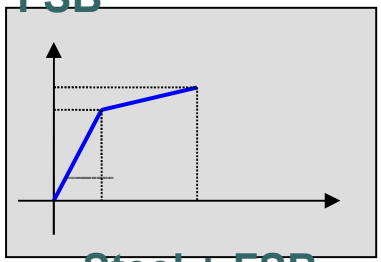
Bearings



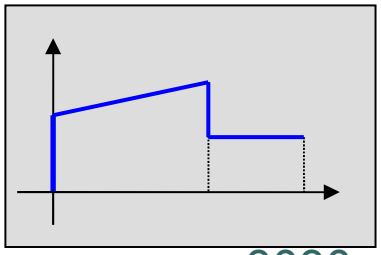
LDRB, HDRB



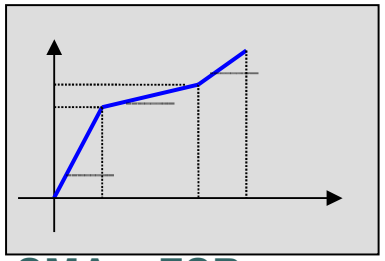
LRB



Steel + FSB



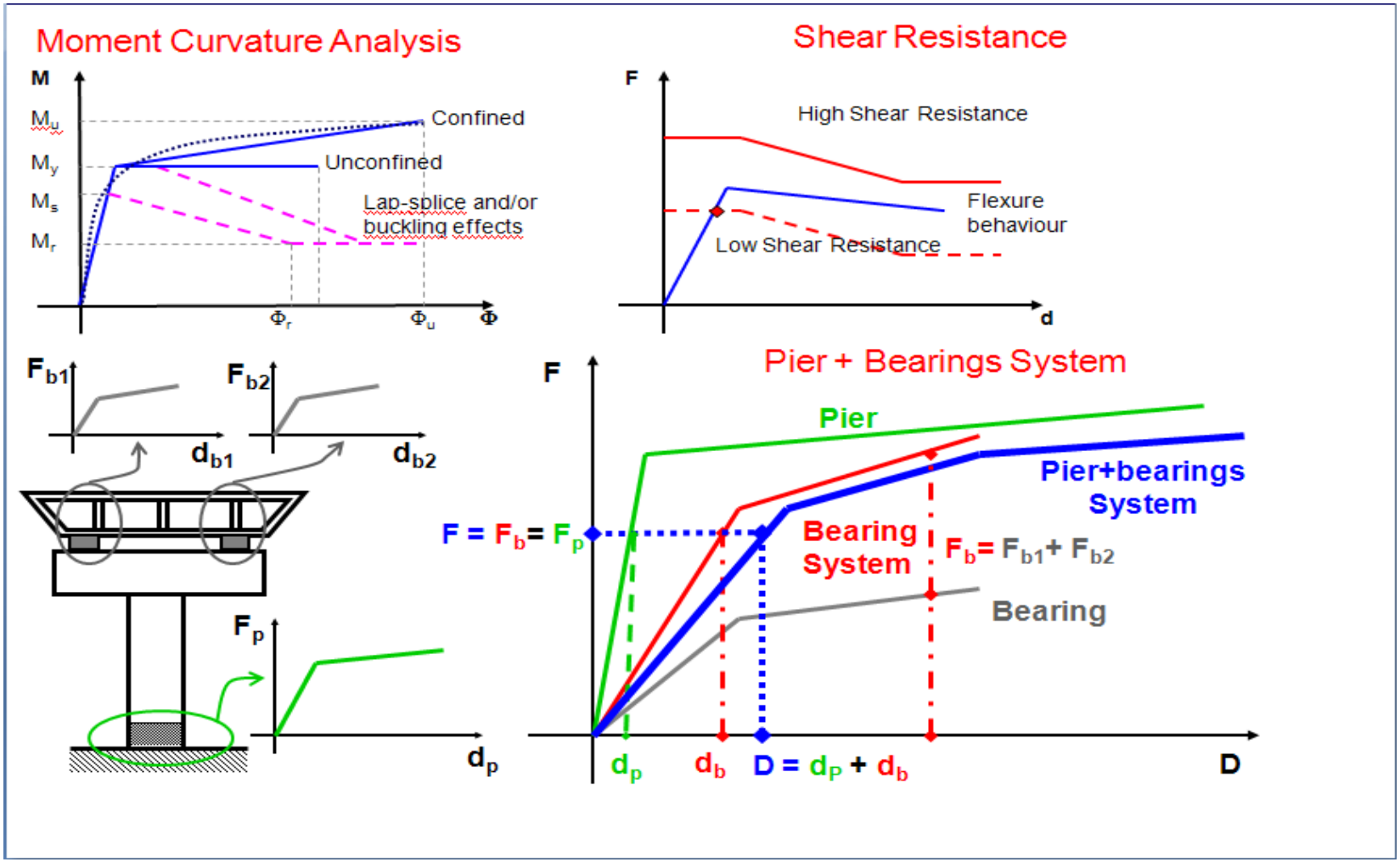
FPS



SMA + FSB

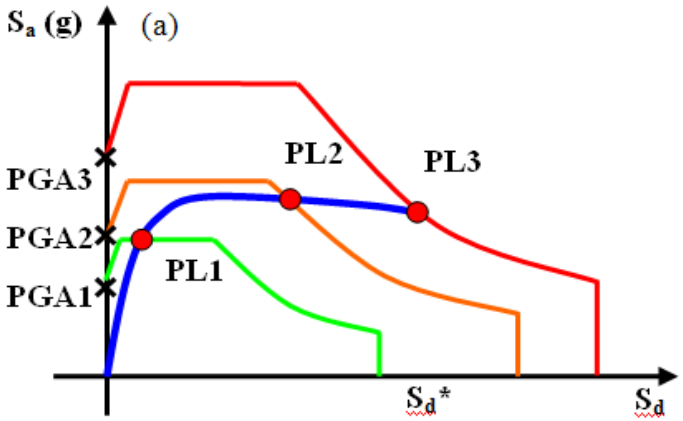
Isolation Systems

Definition of the mechanical behaviour of piers and bearings

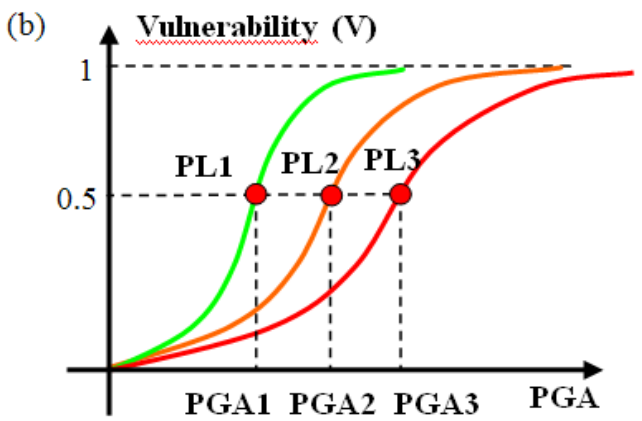


Evaluation of vulnerability and seismic risk

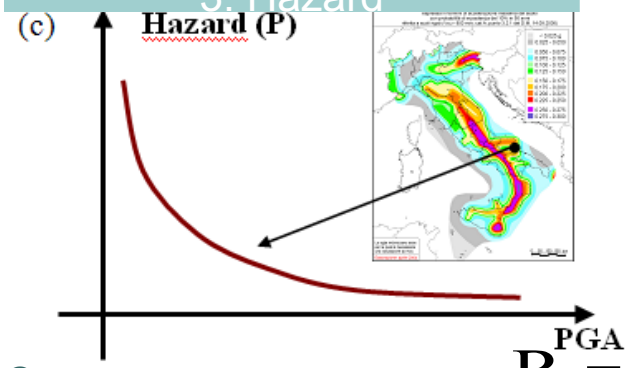
1. Definition of PGA & L.P.



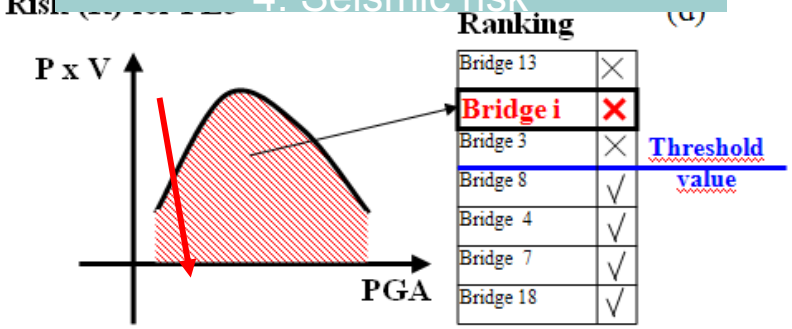
2. Fragility curves



3. Hazard

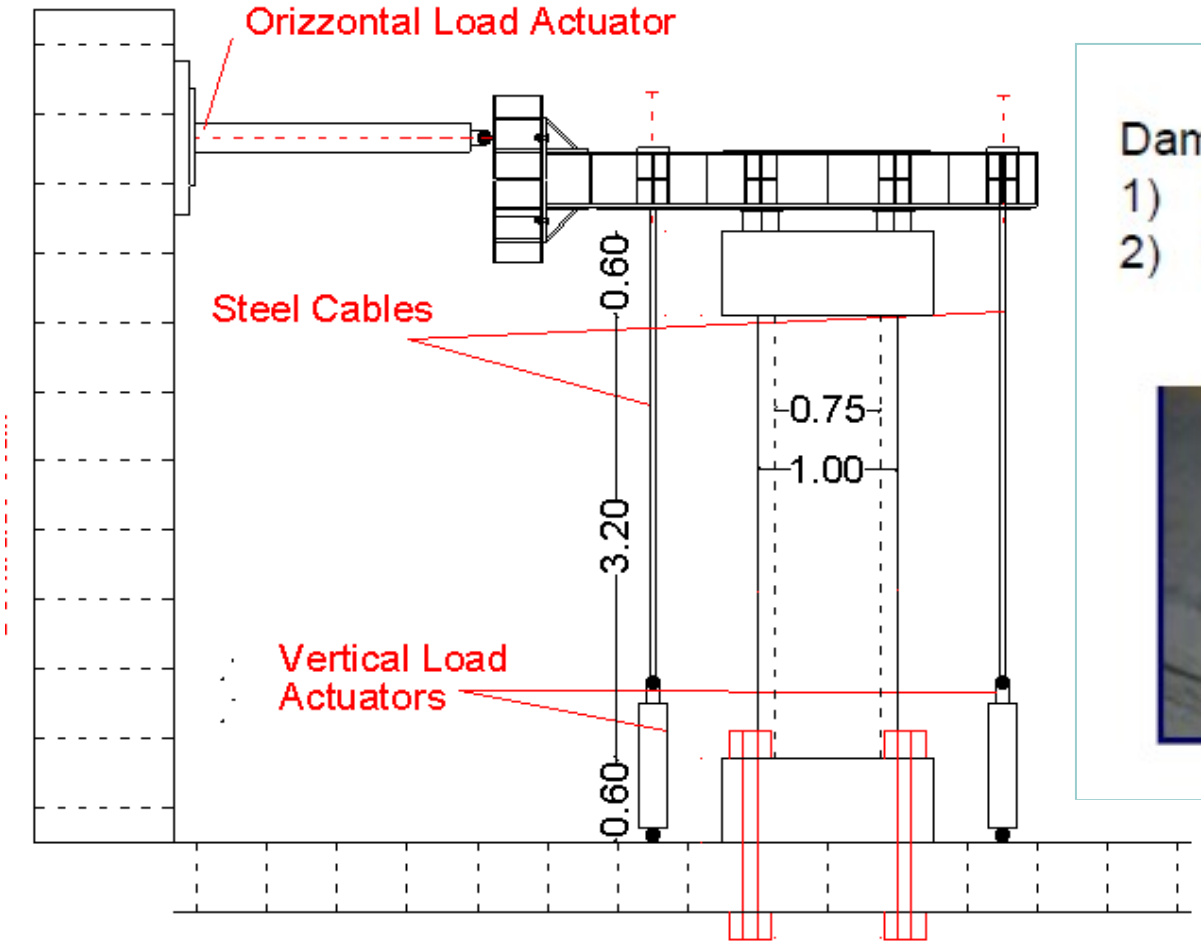


4. Seismic risk



$$R = \int_{PGA} P \times V$$

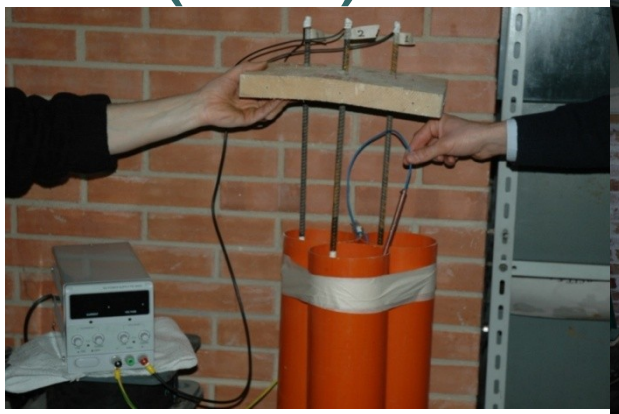
Testing layout: pier+bearing

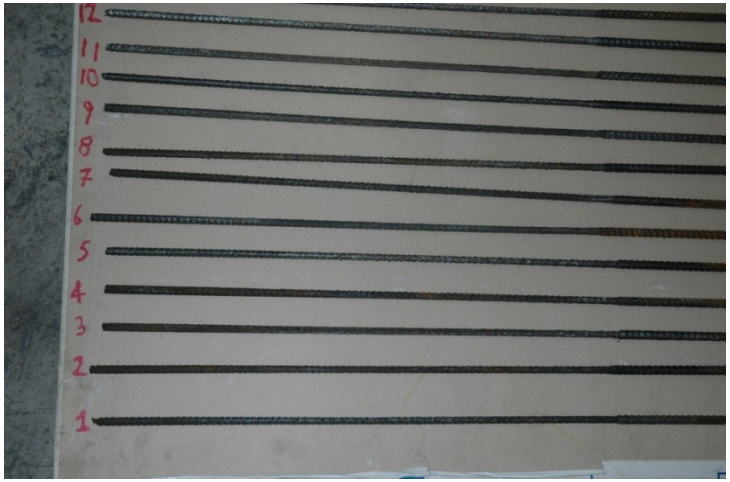


Damage

1) Corroded rebars
2) Real (used) bearings

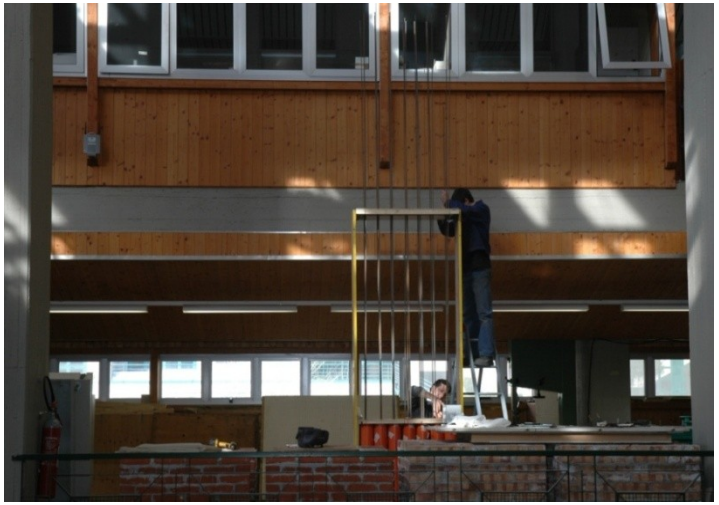
Deterioration process of rebars (1/2)

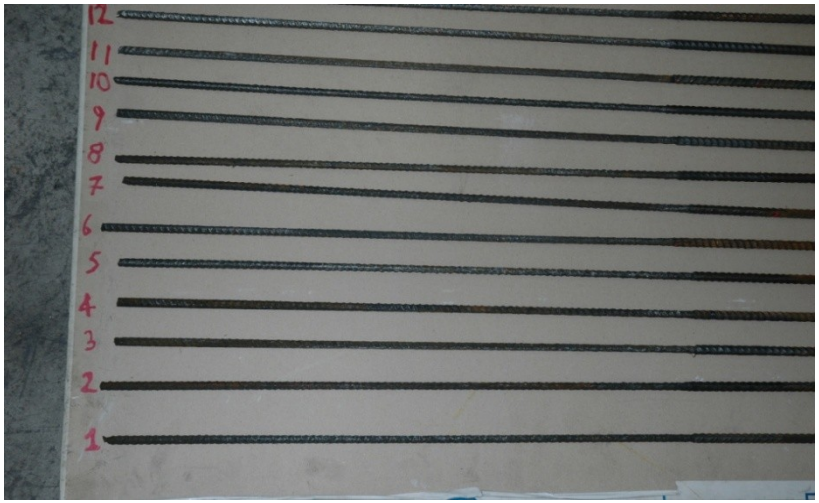


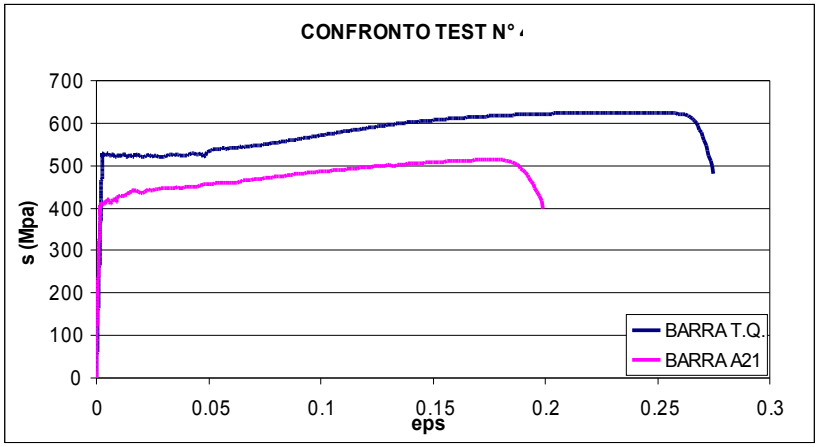


$$\Delta m = \frac{t \times I_{corr}}{3446}$$

Deterioration process of rebars (2/2)







Further topics to be explored

Analytical and experimental investigation of critical bridge components (piers, bearings), under different decay conditions, with a view to improved design procedures and/or effective retrofit measurements

Experimental assessment, quality control and acceptance of bridge bearings under static and dynamic loading (testing campaign on existing bearings)

Calibration and validation of results (ratings from visual inspections)

Thank you for your attention

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